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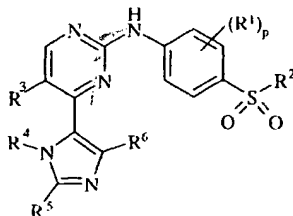
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(54) Title: PYRIMIDINE COMPOUNDS



(I)

(57) Abstract: Compounds of the formula (I) wherein R¹, R², R³, R⁴, R⁵, R⁶ and p are as defined within and a pharmaceutically acceptable salts and (in vivo) hydrolysable esters are described. Also described are processes for their preparation and their use as medicaments, particularly medicaments for producing a cell cycle inhibitory (anti-cell-proliferation) effect in a warm-blooded animal, such as man.

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PYRIMIDINE COMPOUNDS

The invention relates to pyrimidine derivatives, or pharmaceutically acceptable salts or *in vivo* hydrolysable esters thereof, which possess cell-cycle inhibitory activity and are accordingly useful for their anti-cell-proliferation (such as anti-cancer) activity and are therefore useful in methods of treatment of the human or animal body. The invention also relates to processes for the manufacture of said pyrimidine derivatives, to pharmaceutical compositions containing them and to their use in the manufacture of medicaments of use in the production of an anti-cell-proliferation effect in a warm-blooded animal such as man.

A family of intracellular proteins called cyclins play a central role in the cell cycle. The synthesis and degradation of cyclins is tightly controlled such that their level of expression fluctuates during the cell cycle. Cyclins bind to cyclin-dependent serine/threonine kinases (CDKs) and this association is essential for CDK (such as CDK1, CDK2, CDK4 and/or CDK6) activity within the cell. Although the precise details of how each of these factors combine to regulate CDK activity is poorly understood, the balance between the two dictates whether or not the cell will progress through the cell cycle.

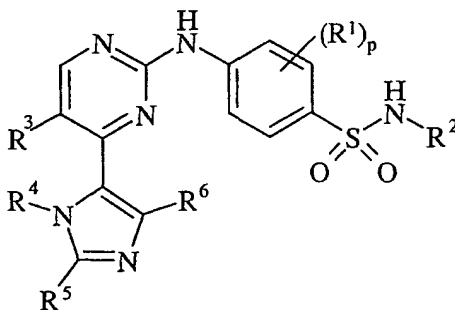
The recent convergence of oncogene and tumour suppressor gene research has identified regulation of entry into the cell cycle as a key control point of mitogenesis in tumours. Moreover, CDKs appear to be downstream of a number of oncogene signalling pathways. Disregulation of CDK activity by upregulation of cyclins and/or deletion of endogenous inhibitors appears to be an important axis between mitogenic signalling pathways and proliferation of tumour cells.

Accordingly it has been recognised that an inhibitor of cell cycle kinases, particularly inhibitors of CDK2, CDK4 and/or CDK6 (which operate at the S-phase, G1-S and G1-S phase respectively) should be of value as a selective inhibitor of cell proliferation, such as growth of mammalian cancer cells.

The present invention is based on the discovery that certain pyrimidine compounds surprisingly inhibit the effects of cell cycle kinases showing selectivity for CDK2, CDK4 and CDK6, and thus possess anti-cell-proliferation properties. Such properties are expected to be of value in the treatment of disease states associated with aberrant cell cycles and cell proliferation such as cancers (solid tumours and leukemias), fibroproliferative and differentiative disorders, psoriasis, rheumatoid arthritis, Kaposi's sarcoma, haemangioma,

acute and chronic nephropathies, atheroma, atherosclerosis, arterial restenosis, autoimmune diseases, acute and chronic inflammation, bone diseases and ocular diseases with retinal vessel proliferation.

Accordingly, the present invention provides a compound of formula (I):



(I)

wherein:

R¹ is halo, cyano, C₁₋₃alkyl or C₁₋₃alkoxy;

p is 0-2; wherein the values of R¹ may be the same or different;

R² is hydrogen, C₁₋₄alkyl, C₂₋₄alkenyl, C₂₋₄alkynyl, C₃₋₆cycloalkyl, C₃₋₆cycloalkylC₁₋₃alkyl, a heterocyclyl or heterocyclylC₁₋₃alkyl; wherein R² may be optionally substituted on carbon by one or more methyl, ethyl, methoxy, ethoxy, propoxy, trifluoromethyl, trifluoromethoxy, 2,2,2-trifluoroethoxy or cyclopropylmethoxy; and wherein if said heterocyclyl contains an -NH- moiety that nitrogen may be optionally substituted by one or more methyl, ethyl, acetyl, 2,2,2-trifluoroethyl or methoxyethyl;

R³ is hydrogen, halo or cyano;

R⁴ is C₁₋₆alkyl or C₁₋₆alkoxyC₁₋₆alkyl;

R⁵ is C₁₋₆alkyl or C₂₋₆alkenyl; wherein R⁵ may be optionally substituted on carbon by one or more methoxy, ethoxy, propoxy, trifluoromethyl, trifluoromethoxy, 2,2,2-trifluoroethoxy or cyclopropylmethoxy;

R⁶ is halo or C₁₋₄alkyl;

or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof;

with the proviso that if R⁴, R⁵ and R⁶ are all methyl then R² is not hydrogen, optionally substituted C₁₋₄alkyl or C₃₋₆cycloalkyl.

In a further aspect of the invention there is provided a compound of formula (I) (as depicted above) wherein:

R¹ is halo, cyano, C₁₋₃alkyl or C₁₋₃alkoxy;

p is 0-2; wherein the values of **R**¹ may be the same or different;

R² is hydrogen, C₁₋₄alkyl, C₂₋₄alkenyl, C₂₋₄alkynyl, C₃₋₆cycloalkyl, C₃₋₆cycloalkylC₁₋₃alkyl, a heterocyclyl or heterocyclylC₁₋₃alkyl; wherein **R**² may be optionally substituted on carbon by one or more methyl, ethyl, methoxy, ethoxy, propoxy, trifluoromethyl, trifluoromethoxy, 2,2,2-trifluoroethoxy or cyclopropylmethoxy; and wherein if said heterocyclyl contains an -NH- moiety that nitrogen may be optionally substituted by one or more methyl, ethyl, acetyl, 2,2,2-trifluoroethyl or methoxyethyl;

R³ is hydrogen, halo or cyano;

R⁴ is C₂₋₆alkyl or C₁₋₆alkoxyC₁₋₆alkyl;

R⁵ is C₁₋₆alkyl or C₂₋₆alkenyl; wherein **R**⁵ may be optionally substituted on carbon by one or more methoxy, ethoxy, propoxy, trifluoromethyl, trifluoromethoxy, 2,2,2-trifluoroethoxy or cyclopropylmethoxy;

R⁶ is C₁₋₄alkyl;

or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof.

In this specification the term "alkyl" includes both straight and branched chain alkyl groups but references to individual alkyl groups such as "propyl" are specific for the straight chain version only. For example, "C₁₋₆alkyl", "C₂₋₆alkyl", "C₁₋₄alkyl", "C₂₋₄alkyl" and "C₁₋₃alkyl" include propyl, isopropyl and *t*-butyl. However, references to individual alkyl groups such as 'propyl' are specific for the straight chained version only and references to individual branched chain alkyl groups such as 'isopropyl' are specific for the branched chain version only. A similar convention applies to other radicals, for example "C₃₋₆cycloalkylC₁₋₃alkyl" includes cyclopropylmethyl, 1-cyclobutylethyl and 3-cyclopropylpropyl. The term "halo" refers to fluoro, chloro, bromo and iodo.

Where optional substituents are chosen from "one or more" groups it is to be understood that this definition includes all substituents being chosen from one of the specified groups or the substituents being chosen from two or more of the specified groups.

A "heterocyclyl" is a saturated, partially saturated or unsaturated, monocyclic ring containing 4-6 atoms of which at least one atom is chosen from nitrogen, sulphur or oxygen, which may, unless otherwise specified, be carbon or nitrogen linked, and a ring sulphur atom may be optionally oxidised to form the S-oxide(s). Examples and suitable values of the term "heterocyclyl" are morpholino, piperidyl, pyridyl, pyranyl, pyrrolyl, isothiazolyl, thienyl, thiadiazolyl, piperazinyl, thiazolidinyl, thiomorpholino, pyrrolinyl, tetrahydropyranyl,

tetrahydrofuryl, imidazolyl, pyrimidyl, pyrazinyl, pyridazinyl and isoxazolyl. Suitably a "heterocyclyl" is tetrahydrofuryl.

Examples of "C₁₋₃alkoxy" include, methoxy, ethoxy and propoxy. Examples of "C₂₋₆alkenyl" and "C₂₋₄alkenyl" are vinyl, allyl and 1-propenyl. Examples of "C₂₋₄alkynyl" are ethynyl, 1-propynyl and 2-propynyl. Examples of "C₃₋₆cycloalkyl" are cyclopropyl, cyclobutyl, cyclopentyl and cyclohexyl. Examples of "heterocyclylC₁₋₃alkyl" include pyridylmethyl, 3-morpholinopropyl and 2-pyrimid-2-ylethyl. Examples of "C₁₋₆alkoxyC₁₋₆alkyl" and "C₁₋₄alkoxyC₁₋₄alkyl" are methoxymethyl, 2-methoxyethyl and 2-ethoxypropyl.

A suitable pharmaceutically acceptable salt of a compound of the invention is, for example, an acid-addition salt of a compound of the invention which is sufficiently basic, for example, an acid-addition salt with, for example, an inorganic or organic acid, for example hydrochloric, hydrobromic, sulphuric, phosphoric, trifluoroacetic, citric or maleic acid. In addition a suitable pharmaceutically acceptable salt of a compound of the invention which is sufficiently acidic is an alkali metal salt, for example a sodium or potassium salt, an alkaline earth metal salt, for example a calcium or magnesium salt, an ammonium salt or a salt with an organic base which affords a physiologically-acceptable cation, for example a salt with methylamine, dimethylamine, trimethylamine, piperidine, morpholine or tris-(2-hydroxyethyl)amine.

An *in vivo* hydrolysable ester of a compound of the formula (I) containing carboxy or hydroxy group is, for example, a pharmaceutically acceptable ester which is hydrolysed in the human or animal body to produce the parent acid or alcohol. Suitable pharmaceutically acceptable esters for carboxy include C₁₋₆alkoxymethyl esters for example methoxymethyl, C₁₋₆alkanoyloxymethyl esters for example pivaloyloxymethyl, phthalidyl esters, C₃₋₈cycloalkoxycarbonyloxyC₁₋₆alkyl esters for example 1-cyclohexylcarbonyloxyethyl; 1,3-dioxolen-2-onylmethyl esters for example 5-methyl-1,3-dioxolen-2-onylmethyl; and C₁₋₆alkoxycarbonyloxyethyl esters for example 1-methoxycarbonyloxyethyl and may be formed at any carboxy group in the compounds of this invention.

An *in vivo* hydrolysable ester of a compound of the formula (I) containing a hydroxy group includes inorganic esters such as phosphate esters and α -acyloxyalkyl ethers and related compounds which as a result of the *in vivo* hydrolysis of the ester breakdown to give the parent hydroxy group. Examples of α -acyloxyalkyl ethers include acetoxymethoxy and 2,2-dimethylpropionyloxy-methoxy. A selection of *in vivo* hydrolysable ester forming groups

for hydroxy include alkanoyl, benzoyl, phenylacetyl and substituted benzoyl and phenylacetyl, alkoxy carbonyl (to give alkyl carbonate esters), dialkylcarbamoyl and *N*-(dialkylaminoethyl)-*N*-alkylcarbamoyl (to give carbamates), dialkylaminoacetyl and carboxyacetyl. Examples of substituents on benzoyl include morpholino and piperazino linked
5 from a ring nitrogen atom via a methylene group to the 3- or 4- position of the benzoyl ring.

Some compounds of the formula (I) may have chiral centres and/or geometric isomeric centres (*E*- and *Z*- isomers), and it is to be understood that the invention encompasses all such optical, diastereoisomers and geometric isomers that possess CDK inhibitory activity.

The invention relates to any and all tautomeric forms of the compounds of the formula
10 (I) that possess CDK inhibitory activity. In particular the skilled reader will appreciate that when R⁴ is hydrogen, the imidazole ring as drawn in formula (I) may tautomerise.

It is also to be understood that certain compounds of the formula (I) can exist in solvated as well as unsolvated forms such as, for example, hydrated forms. It is to be understood that the invention encompasses all such solvated forms which possess CDK
15 inhibitory activity.

Suitable values of R¹, R², R³, R⁴, R⁵, R⁶ and p are as follows. Such values may be used where appropriate with any of the definitions, claims or embodiments defined hereinbefore or wherein:

R¹ is fluoro, chloro, cyano, methyl, ethyl, methoxy or ethoxy.

20 p is 0.

p is 1.

p is 2; wherein the values of R¹ may be the same or different.

R² is hydrogen or C₁₋₄alkyl; wherein R² may be optionally substituted on carbon by one or more methoxy or ethoxy.

25 R² is hydrogen, C₁₋₄alkyl or heterocyclylC₁₋₃alkyl; wherein R² may be optionally substituted on carbon by one or more methoxy or ethoxy.

R² is hydrogen, methyl, ethyl or propyl; wherein R² may be optionally substituted on carbon by one or more methoxy or ethoxy.

30 R² is hydrogen, methyl, ethyl, propyl or 2-pyrazolyethyl; wherein R² may be optionally substituted on carbon by one or more methoxy or ethoxy.

R² is hydrogen, 2-methoxyethyl, methyl, 3-methoxypropyl or 2-ethoxyethyl.

R² is hydrogen, 2-methoxyethyl, methyl, 3-methoxypropyl or 2-ethoxyethyl or 2-pyrazol-1-ylethyl.

R³ is hydrogen.

R³ is hydrogen or halo.

5 R³ is hydrogen or bromo.

R⁴ is C₂₋₄alkyl.

R⁴ is C₁₋₄alkyl.

R⁴ is ethyl or isopropyl.

R⁴ is methyl, ethyl or isopropyl.

10 R⁵ is C₁₋₆alkyl.

R⁵ is C₁₋₄alkyl.

R⁵ is methyl or ethyl.

R⁶ is methyl.

R⁶ is methyl or halo.

15 R⁶ is methyl or bromo.

Therefore in another aspect of the invention, there is provided a compound of formula (I) (as depicted above) wherein:

p is 0;

20 R² is hydrogen or C₁₋₄alkyl; wherein R² may be optionally substituted on carbon by one or more methoxy or ethoxy;

R³ is hydrogen;

R⁴ is C₂₋₄alkyl;

R⁵ is C₁₋₆alkyl;

R⁶ is methyl;

25 or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof.

Therefore in another aspect of the invention, there is provided a compound of formula (I) (as depicted above) wherein:

p is 0;

30 R² is hydrogen, C₁₋₄alkyl or heterocyclylC₁₋₃alkyl; wherein R² may be optionally substituted on carbon by one or more methoxy or ethoxy;

R³ is hydrogen or halo;

R⁴ is C₁₋₄alkyl;

R⁵ is C₁₋₆alkyl;

R⁶ is methyl or halo;
or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof;
with the proviso that if R⁴, R⁵ and R⁶ are all methyl then R² is not hydrogen or optionally substituted C₁₋₄alkyl.

5 Therefore in an additional aspect of the invention, there is provided a compound of formula (I) (as depicted above) wherein:

p is 0;
R² is hydrogen, 2-methoxyethyl, methyl, 3-methoxypropyl or 2-ethoxyethyl;
R³ is hydrogen;
10 R⁴ is ethyl or isopropyl;
R⁵ is methyl or ethyl;
R⁶ is methyl;

or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof.

15 Therefore in an additional aspect of the invention, there is provided a compound of formula (I) (as depicted above) wherein:

p is 0;
R² is hydrogen, 2-methoxyethyl, methyl, 3-methoxypropyl or 2-ethoxyethyl or
2-pyrazol-1-ylethyl;
R³ is hydrogen or bromo;
20 R⁴ is methyl, ethyl or isopropyl;
R⁵ is methyl or ethyl;
R⁶ is methyl or bromo;

or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof;
with the proviso that if R⁴, R⁵ and R⁶ are all methyl then R² is not hydrogen, 2-methoxyethyl,
25 methyl, 3-methoxypropyl or 2-ethoxyethyl.

In another aspect of the invention, particular compounds of the invention are any one of the Examples or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof.

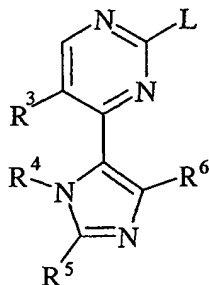
A particular aspect of the invention is that which relates to the compound of formula (I) or a pharmaceutically acceptable salt thereof.

30 Another aspect of the present invention provides a process for preparing a compound of formula (I) or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof

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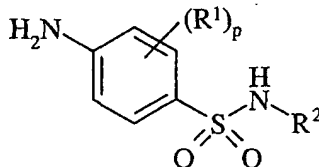
which process (wherein R^1 , R^2 , R^3 , R^4 , R^5 , R^6 and p are, unless otherwise specified, as defined in formula (I)) comprises of:

Process a) reaction of a pyrimidine of formula (II):



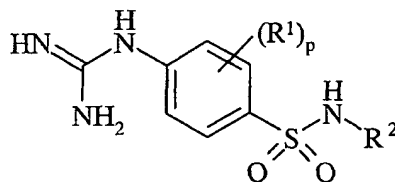
(II)

wherein L is a displaceable group; with an aniline of formula (III):



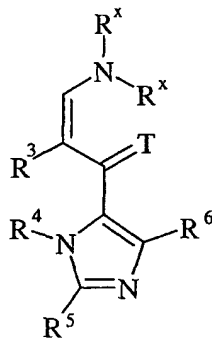
(III)

Process b) reacting a compound of formula (IV):



(IV)

with a compound of formula (V):

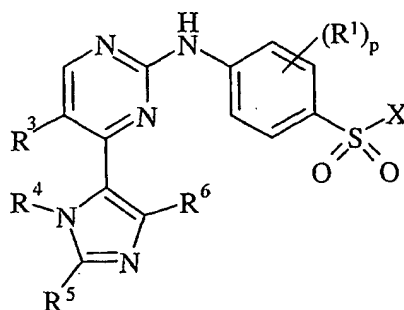


(V)

wherein T is O or S; R^x may be the same or different and is C_{1-6} alkyl;

- 9 -

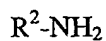
Process c) reacting a pyrimidine of formula (VI):



(VI)

wherein X is a displaceable group; with an amine of formula (VII):

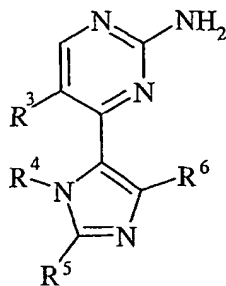
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(VII)

or

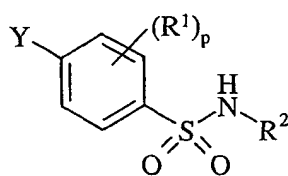
Process d) reacting a pyrimidine of formula (VIII)



(VIII)

10

with a compound of formula (IX):



(IX)

where Y is a displaceable group;

15

and thereafter if necessary:

i) converting a compound of the formula (I) into another compound of the formula (I);

ii) removing any protecting groups;

iii) forming a pharmaceutically acceptable salt or *in vivo* hydrolysable ester.

L is a displaceable group, suitable values for L are for example, a halogeno or

sulphonyloxy group, for example a chloro, bromo, methanesulphonyloxy or toluene-4-sulphonyloxy group.

X is a displaceable group, suitable values for X are for example, a fluoro or chloro group. Preferably X is fluoro.

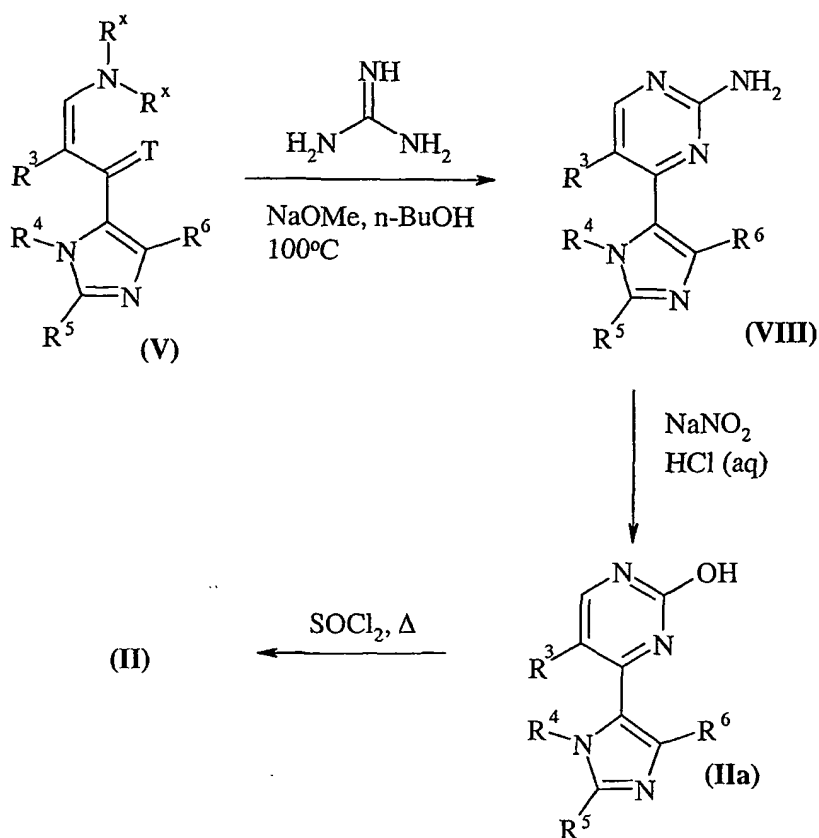
- 5 Y is a displaceable group, suitable values for Y are for example, a halogeno or sulphonyloxy group, for example a bromo, iodo or trifluoromethanesulphonyloxy group. Preferably Y is iodo.

Specific reaction conditions for the above reactions are as follows.

- Process a) Pyrimidines of formula (II) and anilines of formula (III) may be reacted
10 together:
- i) in the presence of a suitable solvent for example a ketone such as acetone or an alcohol such as ethanol or butanol or an aromatic hydrocarbon such as toluene or *N*-methyl pyrrolidine, optionally in the presence of a suitable acid for example an inorganic acid such as hydrochloric acid or sulphuric acid, or an organic acid such as acetic acid or formic acid (or a
15 suitable Lewis acid) and at a temperature in the range of 0°C to reflux, preferably reflux; or
- ii) under standard Buchwald conditions (for example see *J. Am. Chem. Soc.*, **118**, 7215; *J. Am. Chem. Soc.*, **119**, 8451; *J. Org. Chem.*, **62**, 1568 and 6066) for example in the presence of palladium acetate, in a suitable solvent for example an aromatic solvent such as toluene, benzene or xylene, with a suitable base for example an inorganic base such as caesium
20 carbonate or an organic base such as potassium-*t*-butoxide, in the presence of a suitable ligand such as 2,2'-bis(diphenylphosphino)-1,1'-binaphthyl and at a temperature in the range of 25 to 80°C.

Pyrimidines of the formula (II) where L is chloro may be prepared according to Scheme 1:

- 11 -



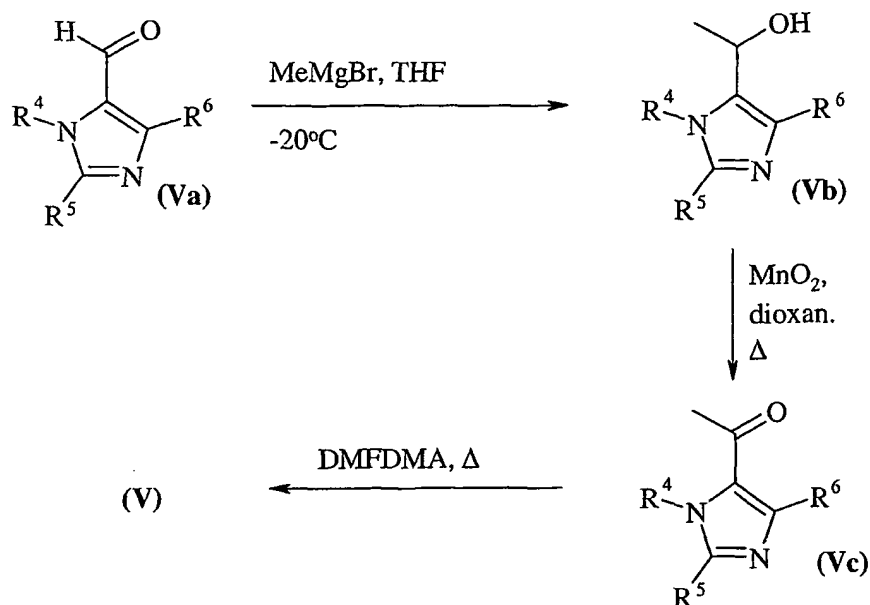
Scheme 1

Anilines of formula (III) are commercially available compounds, or they are known in the literature, or they are prepared by standard processes known in the art.

- 5 *Process b)* Compounds of formula (IV) and compounds of formula (V) are reacted together in a suitable solvent such as *N*-methylpyrrolidinone or butanol at a temperature in the range of $100\text{--}200^\circ\text{C}$, preferably in the range of $150\text{--}170^\circ\text{C}$. The reaction is preferably conducted in the presence of a suitable base such as, for example, sodium hydride, sodium methoxide or potassium carbonate.

- 10 Compounds of formula (V) may be prepared according to *Scheme 2*:

- 12 -



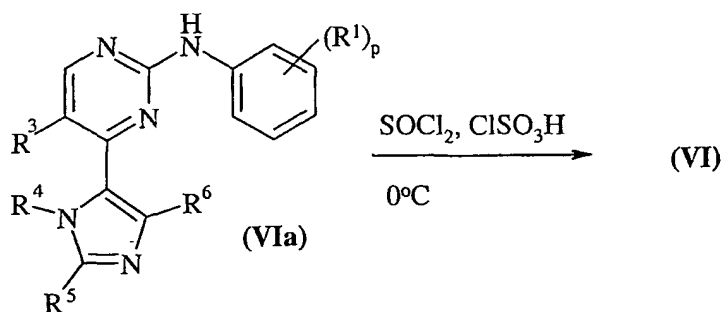
Scheme 2

Compounds of formula (IV) and (Va) are commercially available compounds, or they are known in the literature, or they are prepared by standard processes known in the art.

- 5 *Process c*) Compounds of formula (VI) and amines of formula (VII) may be reacted together in the presence of an inert solvent such as *N*-methylpyrrolidinone or pyridine, in the presence of a base for example an inorganic base such as caesium carbonate or in the presence of an organic base such as excess (VII) and at a temperature in the range of 25 to 80°C.

Compounds of formula (VI) (wherein X is chloro) may be prepared according to

- 10 *Scheme 3*:



Scheme 3

Compounds of formula (VIa) may be prepared according to *Process a*, *Process b* or *Process d* but wherein compounds (III), (IV) and (IX) are not substituted by R²NHSO₂⁻.

- 15 *Process d*) Compounds of formula (VIII) and amines of formula (IX) may be reacted together under standard Buchwald conditions as described in *Process a*.

The synthesis of compounds of formula (VIII) is described in *Scheme 1*.

Compounds of formula (IX) are commercially available compounds, or they are known in the literature, or they are prepared by standard processes known in the art.

Amines of formula (VI) are commercially available compounds, or they are known in the literature, or they are prepared by standard processes known in the art.

It will be appreciated that certain of the various ring substituents in the compounds of the present invention may be introduced by standard aromatic substitution reactions or generated by conventional functional group modifications either prior to or immediately following the processes mentioned above, and as such are included in the process aspect of the invention. Such reactions and modifications include, for example, introduction of a substituent by means of an aromatic substitution reaction, reduction of substituents, alkylation of substituents and oxidation of substituents. The reagents and reaction conditions for such procedures are well known in the chemical art. Particular examples of aromatic substitution reactions include the introduction of a nitro group using concentrated nitric acid, the introduction of an acyl group using, for example, an acyl halide and Lewis acid (such as aluminium trichloride) under Friedel Crafts conditions; the introduction of an alkyl group using an alkyl halide and Lewis acid (such as aluminium trichloride) under Friedel Crafts conditions; and the introduction of a halogeno group. Particular examples of modifications include the reduction of a nitro group to an amino group by for example, catalytic hydrogenation with a nickel catalyst or treatment with iron in the presence of hydrochloric acid with heating; oxidation of alkylthio to alkylsulphinyl or alkylsulphonyl.

It will also be appreciated that in some of the reactions mentioned herein it may be necessary/desirable to protect any sensitive groups in the compounds. The instances where protection is necessary or desirable and suitable methods for protection are known to those skilled in the art. Conventional protecting groups may be used in accordance with standard practice (for illustration see T.W. Green, *Protective Groups in Organic Synthesis*, John Wiley and Sons, 1991). Thus, if reactants include groups such as amino, carboxy or hydroxy it may be desirable to protect the group in some of the reactions mentioned herein.

A suitable protecting group for an amino or alkylamino group is, for example, an acyl group, for example an alkanoyl group such as acetyl, an alkoxycarbonyl group, for example a methoxycarbonyl, ethoxycarbonyl or *t*-butoxycarbonyl group, an arylmethoxycarbonyl group, for example benzyloxycarbonyl, or an aroyl group, for example benzoyl. The deprotection conditions for the above protecting groups necessarily vary with the choice of protecting

group. Thus, for example, an acyl group such as an alkanoyl or alkoxycarbonyl group or an aroyl group may be removed for example, by hydrolysis with a suitable base such as an alkali metal hydroxide, for example lithium or sodium hydroxide. Alternatively an acyl group such as a *t*-butoxycarbonyl group may be removed, for example, by treatment with a suitable acid
5 as hydrochloric, sulphuric or phosphoric acid or trifluoroacetic acid and an arylmethoxycarbonyl group such as a benzyloxycarbonyl group may be removed, for example, by hydrogenation over a catalyst such as palladium-on-carbon, or by treatment with a Lewis acid for example boron tris(trifluoroacetate). A suitable alternative protecting group for a primary amino group is, for example, a phthaloyl group which may be removed by treatment
10 with an alkylamine, for example dimethylaminopropylamine, or with hydrazine.

A suitable protecting group for a hydroxy group is, for example, an acyl group, for example an alkanoyl group such as acetyl, an aroyl group, for example benzoyl, or an arylmethyl group, for example benzyl. The deprotection conditions for the above protecting groups will necessarily vary with the choice of protecting group. Thus, for example, an acyl
15 group such as an alkanoyl or an aroyl group may be removed, for example, by hydrolysis with a suitable base such as an alkali metal hydroxide, for example lithium or sodium hydroxide. Alternatively an arylmethyl group such as a benzyl group may be removed, for example, by hydrogenation over a catalyst such as palladium-on-carbon.

A suitable protecting group for a carboxy group is, for example, an esterifying group,
20 for example a methyl or an ethyl group which may be removed, for example, by hydrolysis with a base such as sodium hydroxide, or for example a *t*-butyl group which may be removed, for example, by treatment with an acid, for example an organic acid such as trifluoroacetic acid, or for example a benzyl group which may be removed, for example, by hydrogenation over a catalyst such as palladium-on-carbon.

25 The protecting groups may be removed at any convenient stage in the synthesis using conventional techniques well known in the chemical art.

As stated hereinbefore the compounds defined in the present invention possesses anti-cell-proliferation activity such as anti-cancer activity which is believed to arise from the CDK inhibitory activity of the compound. These properties may be assessed, for example,
30 using the procedures set out in WO 02/04429.

Although the pharmacological properties of the compounds of the formula (I) vary with structural change, in general activity possessed by compounds of the formula (I) may be

demonstrated at IC₅₀ concentrations or doses in the range 250µM to 1nM in the *in vitro* assay described in WO 02/04429.

Typical IC₅₀ values for compounds of the invention when tested in the SRB assay described in WO 02/04429 are in the range 1mM to 1nM.

5 According to a further aspect of the invention there is provided a pharmaceutical composition which comprises a pyrimidine derivative of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as defined hereinbefore in association with a pharmaceutically-acceptable diluent or carrier.

10 The composition may be in a form suitable for oral administration, for example as a tablet or capsule, for parenteral injection (including intravenous, subcutaneous, intramuscular, intravascular or infusion) as a sterile solution, suspension or emulsion, for topical administration as an ointment or cream or for rectal administration as a suppository.

In general the above compositions may be prepared in a conventional manner using conventional excipients.

15 The compound of formula (I) will normally be administered to a warm-blooded animal at a unit dose within the range 5-5000 mg per square meter body area of the animal, i.e. approximately 0.1-100 mg/kg, and this normally provides a therapeutically-effective dose. A unit dose form such as a tablet or capsule will usually contain, for example 1-250 mg of active ingredient. Preferably a daily dose in the range of 1-50 mg/kg is employed. However
20 the daily dose will necessarily be varied depending upon the host treated, the particular route of administration, and the severity of the illness being treated. Accordingly the optimum dosage may be determined by the practitioner who is treating any particular patient.

25 According to a further aspect of the present invention there is provided a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as defined hereinbefore for use in a method of treatment of the human or animal body by therapy.

30 We have found that the compounds defined in the present invention, or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, are effective cell cycle inhibitors (anti-cell proliferation agents), which property is believed to arise from their CDK inhibitory properties. Accordingly the compounds of the present invention are expected to be useful in the treatment of diseases or medical conditions mediated alone or in part by CDK enzymes, i.e. the compounds may be used to produce a CDK inhibitory effect in a warm-blooded animal in need of such treatment. Thus the compounds of the present invention

provide a method for treating the proliferation of malignant cells characterised by inhibition of CDK enzymes, i.e. the compounds may be used to produce an anti-proliferative effect mediated alone or in part by the inhibition of CDKs. Such a compound of the invention is expected to possess a wide range of anti-cancer properties as CDKs have been implicated in many common human cancers such as leukaemia and breast, lung, colon, rectal, stomach, prostate, bladder, pancreas and ovarian cancer. Thus it is expected that a compound of the invention will possess anti-cancer activity against these cancers. It is in addition expected that a compound of the present invention will possess activity against a range of leukaemias, lymphoid malignancies and solid tumours such as carcinomas and sarcomas in tissues such as the liver, kidney, prostate and pancreas. In particular such compounds of the invention are expected to slow advantageously the growth of primary and recurrent solid tumours of, for example, the colon, breast, prostate, lungs and skin. More particularly such compounds of the invention, or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, are expected to inhibit the growth of those primary and recurrent solid tumours which are associated with CDKs, especially those tumours which are significantly dependent on CDKs for their growth and spread, including for example, certain tumours of the colon, breast, prostate, lung, vulva and skin. Particularly "cancer" is selected from leukaemia, breast cancer, lung cancer, colorectal cancer, stomach cancer, prostate cancer, bladder cancer, pancreatic cancer, ovarian cancer, liver cancer, kidney cancer, skin cancer and cancer of the vulva.

It is further expected that a compound of the present invention will possess activity against other cell-proliferation diseases in a wide range of other disease states including leukaemias, fibroproliferative and differentiative disorders, psoriasis, rheumatoid arthritis, Kaposi's sarcoma, haemangioma, acute and chronic nephropathies, atheroma, atherosclerosis, arterial restenosis, autoimmune diseases, acute and chronic inflammation, bone diseases and ocular diseases with retinal vessel proliferation.

Thus according to this aspect of the invention there is provided a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as defined hereinbefore for use as a medicament; and the use of a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as defined hereinbefore in the manufacture of a medicament for use in the production of a cell cycle inhibitory (anti-cell-proliferation) effect in a warm-blooded animal such as man. Particularly, an inhibitory effect is produced by preventing entry into or progression through the S phase by inhibition of CDK2, CDK4 and/or CDK6, especially CDK2.

According to a further feature of the invention, there is provided a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as defined herein before in the manufacture of a medicament for use in the treatment of cancers (solid tumours and leukaemias), fibroproliferative and differentiative disorders, psoriasis, rheumatoid arthritis, Kaposi's sarcoma, haemangioma, acute and chronic nephropathies, atheroma, atherosclerosis, arterial restenosis, autoimmune diseases, acute and chronic inflammation, bone diseases and ocular diseases with retinal vessel proliferation, particularly in the treatment of cancers.

According to a further feature of this aspect of the invention there is provided a method for producing a cell cycle inhibitory (anti-cell-proliferation) effect in a warm-blooded animal, such as man, in need of such treatment which comprises administering to said animal an effective amount of a compound as defined immediately above. Particularly, an inhibitory effect is produced by preventing entry into or progression through the S phase by inhibition of CDK2, CDK4 and/or CDK6, especially CDK2.

According to a further feature of this aspect of the invention there is provided a method for producing a cell cycle inhibitory (anti-cell-proliferation) effect in a warm-blooded animal, such as man, in need of such treatment which comprises administering to said animal an effective amount of a compound of formula (I) or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof as defined herein before. Particularly, an inhibitory effect is produced by preventing entry into or progression through the S phase by inhibition of CDK2, CDK4 and/or CDK6, especially CDK2.

According to an additional feature of this aspect of the invention there is provided a method of treating cancers (solid tumours and leukaemias), fibroproliferative and differentiative disorders, psoriasis, rheumatoid arthritis, Kaposi's sarcoma, haemangioma, acute and chronic nephropathies, atheroma, atherosclerosis, arterial restenosis, autoimmune diseases, acute and chronic inflammation, bone diseases and ocular diseases with retinal vessel proliferation, in a warm-blooded animal, such as man, in need of such treatment which comprises administering to said animal an effective amount of a compound of formula (I) or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof as defined herein before.

Particularly there is provided a method of treating cancer in a warm-blooded animal, such as man, in need of such treatment which comprises administering to said animal an effective amount of a compound of formula (I) or a pharmaceutically acceptable salt or in

vivo hydrolysable ester thereof as defined herein before.

In a further aspect of the invention there is provided a pharmaceutical composition which comprises a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as defined herein before in association with a
5 pharmaceutically-acceptable diluent or carrier for use in the production of a cell cycle inhibitory (anti-cell-proliferation) effect in a warm-blooded animal such as man.

In a further aspect of the invention there is provided a pharmaceutical composition which comprises a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as defined herein before in association with a
10 pharmaceutically-acceptable diluent or carrier for use in the treatment of cancers (solid tumours and leukaemias), fibroproliferative and differentiative disorders, psoriasis, rheumatoid arthritis, Kaposi's sarcoma, haemangioma, acute and chronic nephropathies, atheroma, atherosclerosis, arterial restenosis, autoimmune diseases, acute and chronic inflammation, bone diseases and ocular diseases with retinal vessel proliferation, in a
15 warm-blooded animal such as man.

In a further aspect of the invention there is provided a pharmaceutical composition which comprises a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, as defined herein before in association with a
pharmaceutically-acceptable diluent or carrier for use in the treatment of cancer in a
20 warm-blooded animal such as man.

Preventing cells from entering DNA synthesis by inhibition of essential S-phase initiating activities such as CDK2 initiation may also be useful in protecting normal cells of the body from toxicity of cycle-specific pharmaceutical agents. Inhibition of CDK2 or 4 will prevent progression into the cell cycle in normal cells which could limit the toxicity of
25 cycle-specific pharmaceutical agents which act in S-phase, G2 or mitosis. Such protection may result in the prevention of hair loss normally associated with these agents.

Therefore in a further aspect of the invention there is provided a compound of formula (I) as defined above or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof for use as a cell protective agent.

30 Therefore in a further aspect of the invention there is provided a compound of formula (I) as defined above or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof for use in preventing hair loss arising from the treatment of malignant conditions with

pharmaceutical agents.

Examples of pharmaceutical agents for treating malignant conditions that are known to cause hair loss include alkylating agents such as ifosfamide and cyclophosphamide; antimetabolites such as methotrexate, 5-fluorouracil, gemcitabine and cytarabine; vinca
5 alkaloids and analogues such as vincristine, vinblastine, vindesine, vinorelbine; taxanes such as paclitaxel and docetaxel; topoisomerase I inhibitors such as irinotecan and topotecan; cytotoxic antibiotics such as doxorubicin, daunorubicin, mitoxantrone, actinomycin-D and mitomycin; and others such as etoposide and tretinoin.

In another aspect of the invention, the compound of formula (I), or a pharmaceutically
10 acceptable salt or *in vivo* hydrolysable ester thereof, may be administered in association with a one or more of the above pharmaceutical agents. In this instance the compound of formula (I) may be administered by systemic or non systemic means. Particularly the compound of formula (I) may be administered by non-systemic means, for example topical administration.

Therefore in an additional feature of the invention, there is provided a method of
15 preventing hair loss during treatment for one or more malignant conditions with pharmaceutical agents, in a warm-blooded animal, such as man, which comprises administering to said animal an effective amount of a compound of formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof.

In an additional feature of the invention, there is provided a method of preventing hair
20 loss during treatment for one or more malignant conditions with pharmaceutical agents, in a warm-blooded animal, such as man, which comprises administering to said animal an effective amount of a compound of formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof in simultaneous, sequential or separate administration with an effective amount of said pharmaceutical agent.

25 According to a further aspect of the invention there is provided a pharmaceutical composition for use in preventing hair loss arising from the treatment of malignant conditions with pharmaceutical agents which comprises a compound of formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, and said pharmaceutical agent, in association with a pharmaceutically acceptable diluent or carrier.

30 According to a further aspect of the present invention there is provided a kit comprising a compound of formula (I), or a pharmaceutically acceptable salt or *in vivo*

hydrolysable ester thereof, and a pharmaceutical agent for treating malignant conditions that is known to cause hair loss.

According to a further aspect of the present invention there is provided a kit comprising:

- 5 a) a compound of formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, in a first unit dosage form;
- b) a pharmaceutical agent for treating malignant conditions that is known to cause hair loss; in a second unit dosage form; and
- c) container means for containing said first and second dosage forms.

10 According to another feature of the invention there is provided the use of a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, in the manufacture of a medicament for the prevention of hair loss during treatment of malignant conditions with pharmaceutical agents.

According to a further aspect of the present invention there is provided a combination
15 treatment for the prevention of hair loss comprising the administration of an effective amount of a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, optionally together with a pharmaceutically acceptable diluent or carrier, with the simultaneous, sequential or separate administration of an effective amount of a pharmaceutical agent for treatment of malignant conditions to a warm-blooded animal, such
20 as man.

As stated above the size of the dose required for the therapeutic or prophylactic treatment of a particular cell-proliferation disease will necessarily be varied depending on the host treated, the route of administration and the severity of the illness being treated. A unit dose in the range, for example, 1-100 mg/kg, preferably 1-50 mg/kg is envisaged.

25 The CDK inhibitory activity defined hereinbefore may be applied as a sole therapy or may involve, in addition to a compound of the invention, one or more other substances and/or treatments. Such conjoint treatment may be achieved by way of the simultaneous, sequential or separate administration of the individual components of the treatment. In the field of medical oncology it is normal practice to use a combination of different forms of treatment to
30 treat each patient with cancer. In medical oncology the other component(s) of such conjoint treatment in addition to the cell cycle inhibitory treatment defined hereinbefore may be: surgery, radiotherapy or chemotherapy. Such chemotherapy may cover three main categories of therapeutic agent:

- (i) other cell cycle inhibitory agents that work by the same or different mechanisms from those defined hereinbefore;
- (ii) cytostatic agents such as antioestrogens (for example tamoxifen, toremifene, raloxifene, droloxifene, idoxifene), progestogens (for example megestrol acetate), aromatase inhibitors (for example anastrozole, letrozole, vorazole, exemestane), antiprogestogens, antiandrogens (for example flutamide, nilutamide, bicalutamide, cyproterone acetate), LHRH agonists and antagonists (for example goserelin acetate, luprolide), inhibitors of testosterone 5 α -dihydroreductase (for example finasteride), anti-invasion agents (for example metalloproteinase inhibitors like marimastat and inhibitors of urokinase plasminogen activator receptor function) and inhibitors of growth factor function, (such growth factors include for example platelet derived growth factor and hepatocyte growth factor such inhibitors include growth factor antibodies, growth factor receptor antibodies, tyrosine kinase inhibitors and serine/threonine kinase inhibitors); and
- (iii) antiproliferative/antineoplastic drugs and combinations thereof, as used in medical oncology, such as antimetabolites (for example antifolates like methotrexate, fluoropyrimidines like 5-fluorouracil, purine and adenosine analogues, cytosine arabinoside); antitumour antibiotics (for example anthracyclines like doxorubicin, daunomycin, epirubicin and idarubicin, mitomycin-C, dactinomycin, mithramycin); platinum derivatives (for example cisplatin, carboplatin); alkylating agents (for example nitrogen mustard, melphalan, chlorambucil, busulphan, cyclophosphamide, ifosfamide, nitrosoureas, thiotepea); antimetotic agents (for example vinca alkaloids like vincristine and taxoids like taxol, taxotere); topoisomerase inhibitors (for example epipodophyllotoxins like etoposide and teniposide, amsacrine, topotecan). According to this aspect of the invention there is provided a pharmaceutical product comprising a compound of the formula (I) as defined hereinbefore and an additional anti-tumour substance as defined hereinbefore for the conjoint treatment of cancer.

In addition to their use in therapeutic medicine, the compounds of formula (I) and their pharmaceutically acceptable salts are also useful as pharmacological tools in the development and standardisation of *in vitro* and *in vivo* test systems for the evaluation of the effects of inhibitors of cell cycle activity in laboratory animals such as cats, dogs, rabbits, monkeys, rats and mice, as part of the search for new therapeutic agents.

In the above other pharmaceutical composition, process, method, use and medicament manufacture features, the alternative and preferred embodiments of the compounds of the invention described herein also apply.

Examples

5 The invention will now be illustrated by the following non limiting examples in which, unless stated otherwise:

(i) temperatures are given in degrees Celsius (°C); operations were carried out at room or ambient temperature, that is, at a temperature in the range of 18-25°C;

(ii) organic solutions were dried over anhydrous magnesium sulphate; evaporation of solvent
10 was carried out using a rotary evaporator under reduced pressure (600-4000 Pascals; 4.5-30mmHg) with a bath temperature of up to 60°C;

(iii) chromatography means flash chromatography on silica gel; thin layer chromatography (TLC) was carried out on silica gel plates;

(iv) in general, the course of reactions was followed by TLC and reaction times are given for
15 illustration only;

(v) final products had satisfactory proton nuclear magnetic resonance (NMR) spectra and/or mass spectral data;

(vi) yields are given for illustration only and are not necessarily those which can be obtained by diligent process development; preparations were repeated if more material was required;

(vii) when given, NMR data is in the form of delta values for major diagnostic protons, given
20 in parts per million (ppm) relative to tetramethylsilane (TMS) as an internal standard, determined at 300 MHz using perdeuterio dimethyl sulphoxide (DMSO-d₆) as solvent unless otherwise indicated;

(viii) chemical symbols have their usual meanings; SI units and symbols are used;

25 (ix) solvent ratios are given in volume:volume (v/v) terms; and

(x) mass spectra were run with an electron energy of 70 electron volts in the chemical ionization (CI) mode using a direct exposure probe; where indicated ionization was effected by electron impact (EI), fast atom bombardment (FAB) or electrospray (ESP); values for m/z are given; generally, only ions which indicate the parent mass are reported; and unless

30 otherwise stated, the mass ion quoted is (MH)⁺;

(xi) unless stated otherwise compounds containing an asymmetrically substituted carbon and/or sulphur atom have not been resolved;

(xii) where a synthesis is described as being analogous to that described in a previous example the amounts used are the millimolar ratio equivalents to those used in the previous example;

(xvi) the following abbreviations have been used:

	DMF.DMA	dimethylformamide dimethylacetal;
5	DMA	dimethylacetal;
	EtOAc	ethyl acetate;
	MeOH	methanol; and
	DCM	dichloromethane;

xvii) where an Isolute SCX-2 column is referred to, this means an "ion exchange" extraction
10 cartridge for adsorption of basic compounds, i.e. a polypropylene tube containing a benzenesulphonic acid based strong cation exchange sorbent, used according to the manufacturers instructions obtained from International Sorbent Technologies Limited, Dyffryn Business Park, Hengeod, Mid Glamorgan, UK, CF82 7RJ;

xviii) where an Isolute amine column is referred to, this means an "ion exchange" extraction
15 cartridge for adsorption of acidic compounds, i.e. a polypropylene tube containing a amino silane covalently bonded to a silica particle used according to the manufacturers instructions obtained from International Sorbent Technologies Limited, Dyffryn Business Park, Hengeod, Mid Glamorgan, UK, CF82 7RJ; and

xix) where a Chemelut column is referred to, this means an extraction cartridge for removal of
20 water, i.e. a polypropylene tube containing diatomaceous earth used according to the manufacturers instructions obtained from Varian, Harbor City, California, USA.

Example 1

4-(1,2-Diethyl-4-methylimidazol-5-yl)-2-{4-[N-(2-methoxyethyl)sulphamoyl]anilino}
25 pyrimidine

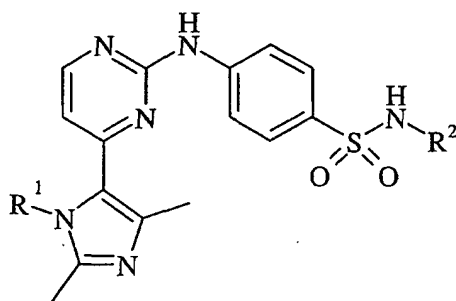
Chlorosulphonic acid (150µl, 2.16mmol) was added dropwise to solution of 2-anilino-4-(1,2-diethyl-4-methylimidazol-5-yl)pyrimidine (Method 13; 28mg, 0.09mmol) in thionyl chloride (2ml) cooled at 0°C and the mixture stirred at 0°C for 10 minutes then heated at 90°C for 90 minutes. The volatiles were removed by evaporation and the residue was dried under
30 high vacuum (<2mmHg) for 1 hour. The resulting solid was placed under nitrogen and a solution of 2-methoxyethylamine (300µl, 3.45mmol) in isopropanol (2ml) added. The mixture was stirred for 30 minutes and the volatiles were evaporated in vacuo. Water (20ml) was

added and extracted EtOAc (2 x 20ml). The organic layers were combined, dried and evaporated in vacuo to give the title compound (16mg, 40%) as a orange solid. NMR 2.35-2.45 (m, 9H), 2.7 (q, 2H), 2.89 (q, 2H), 3.40-3.28 (m, 2H), 3.60-3.58 (m, 3H), 4.35 (m, 2H), 7.0 (d, 1H), 7.49 (t, 1H), 7.70 (d, 2H), 7.9 (d, 2H), 8.55 (d, 1H); m/z 445.

5

Examples 2 - 10

The following compounds were prepared by the procedure of Example 1 using the appropriate starting materials.



Ex	R ¹	R ²	NMR	M/z	SM
2	Et	EtO-(CH ₂) ₂ -	1.05 (m, 6H), 2.24 (s, 3H), 2.35 (s, 3H), 2.87 (q, 2H), 3.34 (m, 4H), 4.30 (q, 2H), 6.92 (d, 1H), 7.42 (t, 1H), 7.70 (d, 2H), 7.90 (d, 2H), 8.52 (d, 1H), 9.90 (s, 1H)	445	Meth 11
3	Et	MeO-(CH ₂) ₃ -	1.16 (t, 3H), 1.59 (q, 2H), 2.25 (s, 3H), 2.38 (s, 3H), 2.75 (q, 2H), 3.17 (s, 3H), 3.26 (m, 2H), 4.35 (q, 2H), 6.97 (d, 1H), 7.34 (t, 1H), 7.69 (d, 2H), 7.94 (d, 2H), 8.53 (d, 1H), 9.90 (s, 1H)	445	Meth 11
4	Et	MeO-(CH ₂) ₂ -	1.06 (t, 3H), 2.24 (s, 3H), 2.35 (s, 3H), 2.87 (q, 2H), 3.16 (s, 3H), 3.28 (m, 2H), 4.35 (q, 2H), 6.98 (d, 1H), 7.45 (t, 1H), 7.70 (d, 2H), 7.90 (d, 2H), 8.55 (d, 1H), 9.89 (s, 1H)	431	Meth 11

Ex	R ¹	R ²	NMR	M/z	SM
5	Et	Me	1.10 (t, 3H), 2.24 (s, 3H), 2.36 (s, 3H), 2.39 (d, 3H), 4.37 (q, 2H), 6.98 (d, 1H), 7.18 (q, 1H), 7.66 (d, 2H), 7.92 (d, 2H), 8.50 (d, 1H), 9.89 (s, 1H)	387	Meth 11
6 ¹	Et	H	1.08 (t, 3H), 2.25 (s, 3H), 2.36 (s, 3H), 4.35 (q, 2H), 6.95 (d, 1H), 7.16 (s, 2H), 7.71 (d, 2H), 7.89 (d, 2H), 8.53 (d, 1H), 9.85 (s, 1H)	373	Meth 11
7	<i>i</i> -Pr	MeO-(CH ₂) ₂ -	1.4 (d, 6H), 2.15 (s, 3H), 2.42 (s, 3H), 2.86 (q, 2H), 3.17 (s, 3H), 3.27 (m, 2H), 4.93 (q, 1H), 6.90 (d, 1H), 7.48 (t, 1H), 7.70 (d, 2H), 7.93 (d, 2H), 8.55 (d, 1H), 9.90 (s, 1H)	445	Meth 12
8	<i>i</i> -Pr	MeO-(CH ₂) ₃ -	1.40 (d, 6H), 1.55 (q, 2H), 2.15 (s, 3H), 2.42 (s, 3H), 2.75 (q, 2H), 3.15 (s, 3H), 3.28 (m, 2H), 4.94 (q, 1H), 6.90 (d, 1H), 7.36 (t, 1H), 7.65 (d, 2H), 7.92 (d, 2H), 8.55 (d, 1H), 9.90 (s, 1H)	459	Meth 12
9 ¹	<i>i</i> -Pr	H	1.45 (d, 6H), 2.15 (s, 3H), 2.45 (s, 3H), 4.95 (q, 1H), 6.92 (d, 1H), 7.16 (s, 2H), 7.70 (d, 2H), 7.90 (d, 2H), 8.55 (d, 1H), 9.95 (s, 1H)	387	Meth 12
10	<i>i</i> -Pr	EtO-(CH ₂) ₂ -	1.05 (t, 3H), 1.40 (d, 6H), 2.18 (s, 3H), 2.39 (s, 3H), 2.85 (q, 2H), 3.32 (m, 2H), 4.94 (q, 1H), 6.92 (d, 1H), 7.45 (t, 1H), 7.69 (d, 2H), 7.93 (d, 2H), 8.55 (d, 1H), 9.90 (s, 1H)	459	Meth 12
11	<i>i</i> -Pr	Me	1.40 (d, 6H), 2.15 (s, 3H), 2.39 (d, 3H), 2.45 (s, 3H), 4.95 (q, 1H), 6.92 (d, 1H), 7.20 (q, 1H), 7.65 (d, 2H), 7.94 (d, 2H), 8.58 (d, 1H), 9.95 (s, 1H)	400	Meth 12

Ex	R ¹	R ²	NMR	M/z	SM
12 2	Me	(pyrazol-1-yl)(CH ₂) ₂ -	2.30 (s, 3H), 2.39 (s, 3H), 3.09 (q, 2H), 3.78 (s, 3H), 4.12 (t, 2H), 6.19 (s, 1H), 7.0 (d, 1H), 7.39 (s, 1H), 7.59 (t, 1H), 7.63 (d, 1H), 7.68 (d, 2H), 7.95 (d, 2H), 8.57 (d, 1H)	453	Ex 31 in WO 02/20512

¹ Purified by flash silica chromatography DCM:MeOH (95:5)

² 9 equivalents of *N,N*-dimethylethylamine were added with 2-(pyrazol-1-yl)ethylamine hydrobromide (Method 14) and the final product was purified by flash silica chromatography DCM:MeOH (96:4)

5

Example 13

4-(4-Bromo-1,2-dimethylimidazol-5-yl)-2-{4-[*N*-(2-methoxyethyl)sulphamoyl]anilino}pyrimidine

A 1M solution of bromine in acetic acid (8.49ml, 8.49mmol) was added to a solution of 4-(1,2-dimethylimidazol-5-yl)-2-{4-[*N*-(2-methoxyethyl)sulphamoyl]anilino}pyrimidine (Example 35 in WO 02/20512; 3.1g, 7.71mmol) in acetic acid (24ml) heated at 70°C under nitrogen. The mixture was stirred at 70°C for 1 hour, allowed to cool, diluted with water and carefully neutralised with saturated aqueous sodium hydrogen carbonate solution. The aqueous solution was extracted with EtOAc, the extracts combined, dried and the volatiles removed by evaporation. The residue was purified by chromatography on silica gel eluting with DCM / MeOH (95:5 increasing in polarity to 90:10) to give the title compound (1g, 24%). NMR: 2.38 (s, 3H), 2.87 (s, 2H), 2.51 (q, 2H), 3.16 (s, 3H), 3.52 (s, 3H), 7.49 (s, 1H), 7.70 (d, 2H), 7.88 (d, 2H), 8.82 (s, 1H).

Preparation of Starting Materials

The starting materials for the examples above are either commercially available or are readily prepared by standard methods from known materials. For example, the following reactions are an illustration, but not a limitation, of some of the starting materials used in the above reactions.

25

Methods 1-8

The following compounds were synthesised by the procedure as described in JOC 1987, 2714-2716.

Meth	Compound	NMR	m/z	SM
1	4-Amino-3,5-dimethylisoxazole	2.03 (s, 3H), 2.19 (s, 3H), 3.75 (brs, 2H)	ND	4-Nitro-3,5-dimethylisoxazole
2	3,5-Methyl-4-(<i>N</i> -acetamido)isoxazole	1.99 (s, 3H), 2.05 (s, 3H), 2.22 (s, 3H), 9.28 (s, 1H).	154	Meth 1
3	3,5-Methyl-4-(ethylamino)isoxazole	1.02 (t, 3H), 2.18 (s, 3H), 2.29 (s, 3H), 2.85 (quin, 2H), 3.70 (s, 1H)	No m/s	Meth 2
4	3,5-Methyl-4-(<i>N</i> -ethyl- <i>N</i> -acetamido)isoxazole	0.96 (t, 3H), 1.70 (s, 3H), 1.92 (s, 3H), 2.34 (s, 3H), 3.24-3.35 (m, 2H)	No m/s	Meth 3
5	5-Acetyl-1-ethyl-2,4-dimethylimidazole	1.15 (t, 3H), 2.30 (s, 3H), 2.4 (d, 6H), 4.18 (q, 2H)	167	Meth 4
6	3,5-Methyl-4-(isopropylamino)isoxazole	1.0 (d, 6H), 2.08 (s, 3H), 2.24 (s, 3H), 2.95-3.04 (m, 1H), 3.44 (d, 1H)	154	4-amino-3,5-methylisoxazole
7	3,5-Methyl-4-(<i>N</i> -isopropyl- <i>N</i> -acetamido)isoxazole	0.98 (t, 6H), 1.63 (s, 3H), 2.10 (s, 3H), 2.32 (s, 3H), 4.67 (m, 1H)		Meth 6
8	5-Acetyl-1-isopropyl-2,4-dimethylimidazole	1.39 (d, 6H), 2.38 (m, 9H), 5.08 (q, 1H)	181	Meth 7

5 **Method 9**5-(3-Dimethylaminoprop-2-en-1-oyl)-1-isopropyl-2,4-dimethylimidazole

5-Acetyl-1-isopropyl-2,4-dimethylimidazole (Method 8; 3g, 16.5mmol) was dissolved in a mixture DMF.DMA (100ml) and the mixture heated under reflux, under an atmosphere of nitrogen, for 18 hours. The volatiles were evaporated in vacuo. The residue was purified by
 10 flash silica chromatography DCM:MeOH (increasing in polarity from 100:0 to 95:5) to give

- 28 -

the title compound (510mg, 13%) as an orange oil. NMR 1.38 (d, 6H), 2.18 (s, 3H), 2.30 (s, 3H), 2.83 (s, 3H), 3.08 (s, 3H), 4.72 (q, 1H), 5.21 (d, 1H), 7.46 (d, 1H); m/z 236

Method 10

5 5-(3-Dimethylaminoprop-2-en-1-oyl)-1-ethyl-2,4-dimethylimidazole

The title compound was prepared from Method 5 by the procedure of Method 9 and used without further purification.

Method 11

10 2-Anilino-4-(1-ethyl-2,4-dimethylimidazol-5-yl)pyrimidine

5-(3-Dimethylaminoprop-2-en-1-oyl)-1-ethyl-2,4-dimethylimidazole (Method 10; 5.65g, 25.6mmol), phenylguanidine hydrogen carbonate (6.05, 30.7mmol) and sodium methoxide (3.47g, 64.2mmol) were suspended in anhydrous DMA (80ml) and the mixture heated at 150°C for 18 hours. The reaction mixture was allowed to cool to ambient temperature and poured into water (50ml). The solution was extracted EtOAc (2 x 50ml). The combined extracts were washed with water (2 x 50ml) and then brine (2 x 50ml), dried and the volatiles removed by evaporation. The residue purified by flash silica chromatography DCM:MeOH (increasing in polarity from 100:0 to 96:4) to give the title compound (5.2g, 70%) as an orange oil. NMR: 1.06 (t, 3H), 2.22 (s, 3H), 2.34 (s, 3H), 4.32 (q, 2H), 6.83 (d, 1H), 6.97 (t, 1H), 7.28 (t, 2H), 7.70 (d, 2H), 8.43 (d, 2H), 9.40 (s, 1H); m/z 294.

Method 12

The following compound was prepared by the procedure of Method 11.

Meth	Compound	NMR	m/z	SM
12	2-Anilino-4-(1-isopropyl-2,4-dimethylimidazol-5-yl)pyrimidine	1.39 (d, 6H), 2.15 (s, 3H), 2.41 (s, 3H), 4.90 (q, 1H), 6.80 (d, 1H), 6.95 (t, 1H), 7.24 (t, 2H), 7.90 (d, 2H), 8.48 (d, 1H), 9.49 (s, 1H)	308	Meth 9

Method 13**2-Anilino-4-(1,2-diethyl-4-methylimidazol-5-yl)pyrimidine**

2-Anilino-4-(1-ethyl-2,4-dimethylimidazol-5-yl)pyrimidine (Method 11; 200mg, 0.68mmol) was dissolved in anhydrous THF (10ml) under an inert atmosphere. The stirring
5 solution was cooled using dry-ice/acetone bath to -70°C . A 1.6M solution of n-butyl lithium in hexane (900 μl , 1.44mmol) was added drop-wise keeping temperature $<-60^{\circ}\text{C}$ until the dark red colour remained. At this point 1.6M n-butyl lithium in hexane (450 μl , 0.72mmol) was added and the solution stirred at -70°C for 10 minutes. Iodomethane (99 μl , 1.50mmol) was added, the temperature was maintained at -70°C for an additional 10 minutes then allowed to
10 rise to room temperature. The reaction was allowed to stir for 1hr at room temperature when water (100ml) was added. The aqueous layer extracted with EtOAc (2 x 20ml). Organics were combined, dried solvent evaporated in vacuo. The residue was purified by flash silica chromatography DCM:MeOH (increasing in polarity from 100:0 to 96:4) to yield the title compound (28mg, 13%). M/z 322.

15

Method 14**2-(Pyrazol-1-yl)ethylamine hydrobromide**

Pyrazole (10.88g, 160mmol), in dry acetonitrile (80ml) was added to solid sodium hydroxide (22.96g, 574mol) and the mixture was stirred for 30 minutes at ambient
20 temperature. Tetrabutylammonium hydrogen sulphate (2.18g, 6.41mmol) and 2-chloroethylamine hydrochloride (19.78g, 172mmol) were added and the mixture heated at reflux for 24 hours. The mixture was allowed to cool, the insolubles removed by filtration and the filtrate evaporated. Excess 49% hydrobromic acid, followed by ethanol (100ml), was added to the residue and the mixture heated to reflux, then cooled in ice. The resulting solid
25 was collected by filtration washed with cold ethanol and dried to give the title compound. NMR: 3.21 (s, 2H), 4.39 (t, 2H), 6.28 (s, 1H), 7.50 (s, 1H), 7.79 (s, 1H), 7.96 (s, 2H).

Example 14

The following illustrate representative pharmaceutical dosage forms containing the
30 compound of formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof (hereafter compound X), for therapeutic or prophylactic use in humans:-

- 30 -

(a): Tablet I	mg/tablet
Compound X	100
Lactose Ph.Eur	182.75
Croscarmellose sodium	12.0
Maize starch paste (5% w/v paste)	2.25
Magnesium stearate	3.0

(b): Tablet II	mg/tablet
Compound X	50
Lactose Ph.Eur	223.75
Croscarmellose sodium	6.0
Maize starch	15.0
Polyvinylpyrrolidone (5% w/v paste)	2.25
Magnesium stearate	3.0

(c): Tablet III	mg/tablet
Compound X	1.0
Lactose Ph.Eur	93.25
Croscarmellose sodium	4.0
Maize starch paste (5% w/v paste)	0.75
Magnesium stearate	1.0

(d): Capsule	mg/capsule
Compound X	10
Lactose Ph.Eur	488.5
Magnesium stearate	1.5

(e): Injection I	(50 mg/ml)
Compound X	5.0% w/v
1M Sodium hydroxide solution	15.0% v/v
0.1M Hydrochloric acid	(to adjust pH to 7.6)
Polyethylene glycol 400	4.5% w/v
Water for injection	to 100%

(f): Injection II	10 mg/ml
Compound X	1.0% w/v
Sodium phosphate BP	3.6% w/v
0.1M Sodium hydroxide solution	15.0% v/v
Water for injection	to 100%

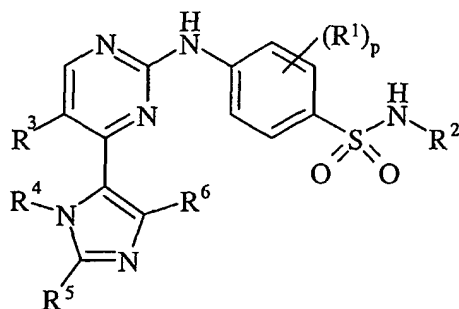
(g): Injection III	(1mg/ml,buffered to pH6)
Compound X	0.1% w/v
Sodium phosphate BP	2.26% w/v
Citric acid	0.38% w/v
Polyethylene glycol 400	3.5% w/v
Water for injection	to 100%

5 Note

The above formulations may be obtained by conventional procedures well known in the pharmaceutical art. The tablets (a)-(c) may be enteric coated by conventional means, for example to provide a coating of cellulose acetate phthalate.

Claims

1. A compound of formula (I):



(I)

wherein:

R¹ is halo, cyano, C₁₋₃alkyl or C₁₋₃alkoxy;

p is 0-2; wherein the values of R¹ may be the same or different;

- R²** is hydrogen, C₁₋₄alkyl, C₂₋₄alkenyl, C₂₋₄alkynyl, C₃₋₆cycloalkyl, C₃₋₆cycloalkylC₁₋₃alkyl, a heterocyclyl or heterocyclylC₁₋₃alkyl; wherein R² may be optionally substituted on carbon by one or more methyl, ethyl, methoxy, ethoxy, propoxy, trifluoromethyl, trifluoromethoxy, 2,2,2-trifluoroethoxy or cyclopropylmethoxy; and wherein if said heterocyclyl contains an -NH- moiety that nitrogen may be optionally substituted by one or more methyl, ethyl, acetyl, 2,2,2-trifluoroethyl or methoxyethyl;

- R³** is hydrogen, halo or cyano;

R⁴ is C₁₋₆alkyl or C₁₋₆alkoxyC₁₋₆alkyl;

R⁵ is C₁₋₆alkyl or C₂₋₆alkenyl; wherein R⁵ may be optionally substituted on carbon by one or more methoxy, ethoxy, propoxy, trifluoromethyl, trifluoromethoxy, 2,2,2-trifluoroethoxy or cyclopropylmethoxy;

- R⁶** is halo or C₁₋₄alkyl;

or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof;

with the proviso that if R⁴, R⁵ and R⁶ are all methyl then R² is not hydrogen, optionally substituted C₁₋₄alkyl or C₃₋₆cycloalkyl.

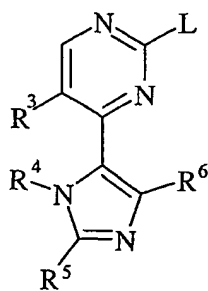
2. A compound of formula (I) according to claim 1 wherein p is 0; or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof.

3. A compound of formula (I) according to claim 1 or 2 wherein R^2 is hydrogen, C_{1-4} alkyl or heterocyclyl C_{1-3} alkyl; wherein R^2 may be optionally substituted on carbon by one or more methoxy or ethoxy; or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof.
- 5
4. A compound of formula (I) according to anyone of claims 1-3 wherein R^3 is hydrogen or halo; or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof.
5. A compound of formula (I) according to anyone of claims 1-4 wherein R^4 is C_{1-4} alkyl; or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof.
- 10
6. A compound of formula (I) according to anyone of claims 1-5 wherein R^5 is C_{1-6} alkyl; or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof.
7. A compound of formula (I) according to anyone of claims 1-6 wherein R^6 is methyl or halo; or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof.
- 15
8. A compound of formula (I) (as depicted in claim 1) wherein:
p is 0;
 R^2 is hydrogen, 2-methoxyethyl, methyl, 3-methoxypropyl or 2-ethoxyethyl or 2-pyrazol-1-ylethyl;
 R^3 is hydrogen or bromo;
 R^4 is methyl, ethyl or isopropyl;
 R^5 is methyl or ethyl;
25 R^6 is methyl or bromo;
or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof;
with the proviso that if R^4 , R^5 and R^6 are all methyl then R^2 is not hydrogen, 2-methoxyethyl, methyl, 3-methoxypropyl or 2-ethoxyethyl.
- 30
9. A compound of formula (I) (as depicted in claim 1) selected from:
4-(1,2-diethyl-4-methylimidazol-5-yl)-2-{4-[N-(2-methoxyethyl)sulphamoyl]anilino}
pyrimidine;

- 4-(1-ethyl-2,4-dimethylimidazol-5-yl)-2-{4-[N-(2-ethoxyethyl)sulphamoyl]anilino}
pyrimidine;
- 4-(1-ethyl-2,4-dimethylimidazol-5-yl)-2-{4-[N-(3-methoxypropyl)sulphamoyl]anilino}
pyrimidine;
- 5 4-(1-ethyl-2,4-dimethylimidazol-5-yl)-2-{4-[N-(2-methoxyethyl)sulphamoyl]anilino}
pyrimidine;
- 4-(1-ethyl-2,4-dimethylimidazol-5-yl)-2-{4-[N-(methyl)sulphamoyl]anilino}pyrimidine;
- 4-(1-ethyl-2,4-dimethylimidazol-5-yl)-2-(4-sulphamoylanilino)pyrimidine;
- 4-(1-isopropyl-2,4-dimethylimidazol-5-yl)-2-{4-[N-(2-methoxyethyl)sulphamoyl]anilino}
pyrimidine;
- 10 4-(1-isopropyl-2,4-dimethylimidazol-5-yl)-2-{4-[N-(3-methoxypropyl)sulphamoyl]anilino}
pyrimidine;
- 4-(1-isopropyl-2,4-dimethylimidazol-5-yl)-2-(4-sulphamoylanilino)pyrimidine;
- 4-(1-isopropyl-2,4-dimethylimidazol-5-yl)-2-{4-[N-(2-ethoxyethyl)sulphamoyl]anilino}
pyrimidine;
- 15 4-(1-isopropyl-2,4-dimethylimidazol-5-yl)-2-{4-[N-(methyl)sulphamoyl]anilino}pyrimidine;
- 4-(1,2,4-trimethylimidazol-5-yl)-2-{4-[N-(2-pyrazol-1-ylethyl)sulphamoyl]anilino}
pyrimidine; or
- 4-(4-bromo-1,2-dimethylimidazol-5-yl)-2-{4-[N-(2-methoxyethyl)sulphamoyl]anilino}
pyrimidine;
- 20 or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof.

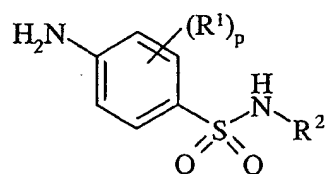
10. A process for preparing a compound of formula (I) or a pharmaceutically acceptable salt or an *in vivo* hydrolysable ester thereof which process (wherein R¹, R², R³, R⁴, R⁵, R⁶ and p are, unless otherwise specified, as defined in claim 1) comprises of:
- 25 *Process a)* reaction of a pyrimidine of formula (II):

- 35 -



(II)

wherein L is a displaceable group; with an aniline of formula (III):

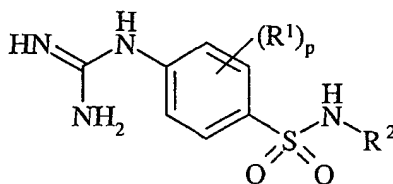


(III)

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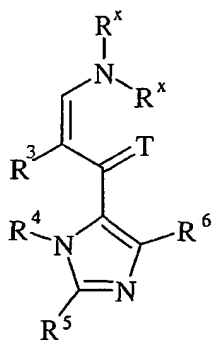
or

Process b) reacting a compound of formula (IV):



(IV)

10 with a compound of formula (V):

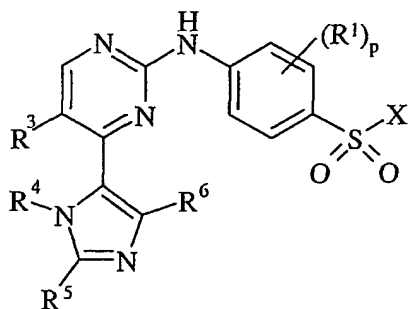


(V)

wherein T is O or S; R^x may be the same or different and is C₁₋₆alkyl;

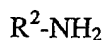
Process c) reacting a pyrimidine of formula (VI):

- 36 -



(VI)

wherein X is a displaceable group; with an amine of formula (VII):

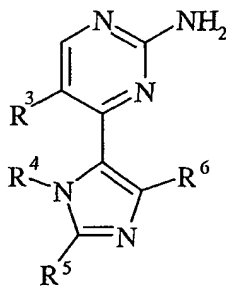


(VII)

5

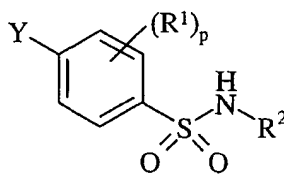
or

Process d) reacting a pyrimidine of formula (VIII)



(VIII)

10 with a compound of formula (IX):



(IX)

where Y is a displaceable group;

and thereafter if necessary:

- 15 i) converting a compound of the formula (I) into another compound of the formula (I);
 ii) removing any protecting groups;
 iii) forming a pharmaceutically acceptable salt or *in vivo* hydrolysable ester.

11. A pharmaceutical composition which comprises a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, according to any one of claims 1-9, in association with a pharmaceutically-acceptable diluent or carrier.
- 5 12. A compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, according to any one of claims 1-9, for use in a method of treatment of the human or animal body by therapy.
13. A compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo*
10 hydrolysable ester thereof, according to any one of claims 1-9, for use as a medicament.
14. The use of a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, according to any one of claims 1-9, in the manufacture of a medicament for use in the production of a cell cycle inhibitory (anti-cell-proliferation) effect
15 in a warm-blooded animal such as man.
15. The use of a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, according to any one of claims 1-9, in the manufacture of a medicament for use in the treatment of cancers (solid tumours and leukaemias),
20 fibroproliferative and differentiative disorders, psoriasis, rheumatoid arthritis, Kaposi's sarcoma, haemangioma, acute and chronic nephropathies, atheroma, atherosclerosis, arterial restenosis, autoimmune diseases, acute and chronic inflammation, bone diseases and ocular diseases with retinal vessel proliferation.
- 25 16. The use of a compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, according to any one of claims 1-9, in the manufacture of a medicament for use in the treatment of cancer.
17. The use according to claim 16 wherein the cancer is selected from leukaemia, breast
30 cancer, lung cancer, colorectal cancer, stomach cancer, prostate cancer, bladder cancer, pancreatic cancer, ovarian cancer, liver cancer, kidney cancer, skin cancer and cancer of the vulva.

18. A compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, according to any one of claims 1-9, for use in the production of a cell cycle inhibitory (anti-cell-proliferation) effect in a warm-blooded animal such as man.
- 5 19. A compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, according to any one of claims 1-9, for use in the treatment of cancers (solid tumours and leukaemias), fibroproliferative and differentiative disorders, psoriasis, rheumatoid arthritis, Kaposi's sarcoma, haemangioma, acute and chronic nephropathies, atheroma, atherosclerosis, arterial restenosis, autoimmune diseases, acute and
10 chronic inflammation, bone diseases and ocular diseases with retinal vessel proliferation.
20. A compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, according to any one of claims 1-9, for use in the treatment of cancer.
- 15 21. A compound of the formula (I), or a pharmaceutically acceptable salt or *in vivo* hydrolysable ester thereof, according to any one of claims 1-9, for use in the treatment of leukaemia, breast cancer, lung cancer, colorectal cancer, stomach cancer, prostate cancer, bladder cancer, pancreatic cancer, ovarian cancer, liver cancer, kidney cancer, skin cancer and
20 cancer of the vulva.

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB 03/00904

A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 C07D403/04 A61K31/506 A61P35/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07D A61K A61P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

CHEM ABS Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 01 14375 A (ASTRAZENECA) 1 March 2001 (2001-03-01) claims; examples 40-95 ---	1, 10-21
P, X	WO 02 20512 A (ASTRAZENECA) 14 March 2002 (2002-03-14) the whole document -----	1-21

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

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11 June 2003

Date of mailing of the international search report

23/06/2003

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/GB 03/00904

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